Hydrophobic and hydrophilic magnetite nanoparticles: non-polar and polar magnetic nanofluids designed for magnetic carriers manufacturing

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High magnetic moment nano – or micron sized carriers with superparamagnetic behavior and various added functionalities provide advanced therapeutic, diagnostic or bioprocessing capabilities [1]. The strongly magnetoresponsive character and appropriate design of surface properties are among the main requirements for nano- or micro-adsorbents to be used in magnetic bio-separation processes, such as protein purification [2] involving high gradient magnetic separation (HGMS) step [3]. The building blocks for the fabrication of magnetoresponsive microcarriers are the subdomain magnetite nanoparticles surface coated by biocompatible molecular layers, such as carboxylic (lauric, myristic, oleic) acids, which ensure their stabilization-dispersion in an appropriate carrier liquid, to obtain stable magnetic nanofluids - the primary materials for the envisaged magnetic nanocomposites.

In this work we report on kg scale synthesis of magnetite nanoparticles with biocompatible coating used as primary particles for the preparation of magnetoresponsive hybrid nanocomposites designed for magnetic separation [4] or drug targeting [5]. Controlled clusterization of magnetite nanoparticles from light hydrocarbon or water based magnetic nanofluids is a widely applied procedure to synthesize polymer-magnetic nanoparticles hybrid microspheres with sizes well above 50 nm having both high magnetic moment and superparamagnetic behavior [4, 5]. The synthesis procedures of magnetite nanofluids (fig.1) using the chemical co-precipitation method developed on laboratory level [6] were optimized and scaled up to achieve the main characteristics required for the preparation of magnetoresponsive microspheres. The procedures were validated by using the data of TEM, DLS, SLS, VSM, magnetogranulometry and rotational rheometry investigations: mean particle size 6-9 nm (figs.2 and 3), biocompatible surface coating (vegetable origin oleic acid; Merck product), high colloidal stability (reduced fraction of small agglomerates; hydrodynamic mean size below 50 nm, figs.4 and 5), well screened magnetic dipole-dipole interactions between particles also at close packing (fig.6; φ_ρ= 0.2 corresponds to approx. 0.5 hydrodynamic volume fraction); superparamagnetic behavior and high specific magnetic moment of surfacted magnetite nanoparticles (fig.7; approx. 50 emu/g), reduced costs.

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References

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Figures

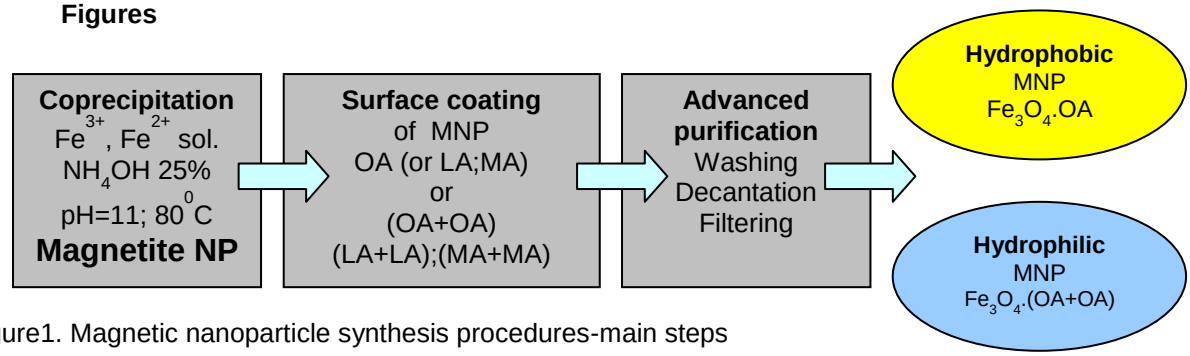

Figure1. Magnetic nanoparticle synthesis procedures-main steps

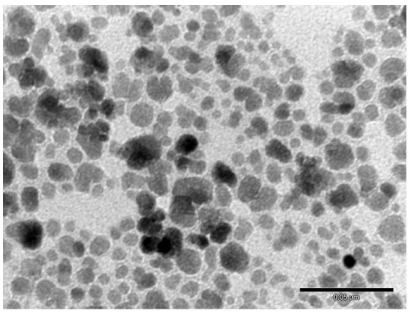

Figure 2. TEM of magnetite NPs dispersed in hydrocarbon carrier liquid

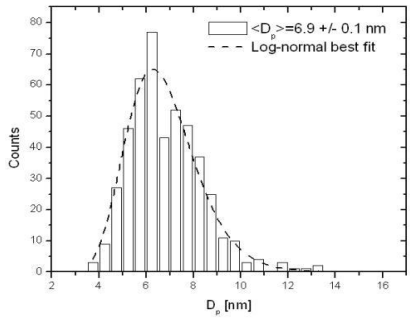

Figure 3. Size distribution of magnetite NPs

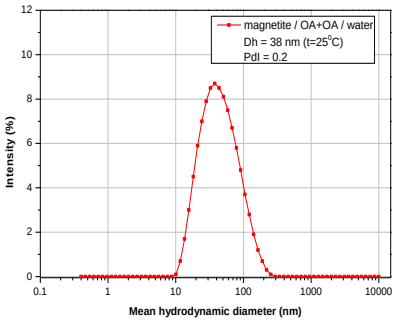

Figure 4. Hydrodynamic size distribution of hydrophilic magnetite NPs (Fe_3O_4.(OA+OA))

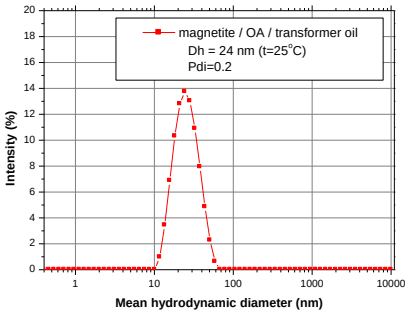

Figure 5.Hydrodynamic size distribution of hydrophobic magnetite NPs (Fe_3O_4.OA)

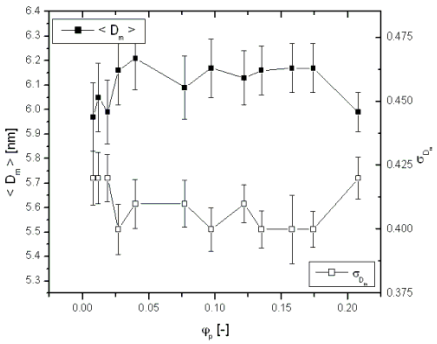

Figure 6. Dependence of magnetic mean size and standard deviation on the solid volume fraction of magnetite NPs dispersed in hydrocarbon carrier

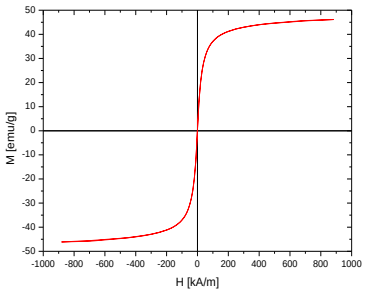

Figure 7. Full magnetization curve for hydrophobic magnetite organosol (Fe3O4.OA)